

Title: This Will Take Your Breath Away

Brief Overview:

The students will use the CBL, TI-82/83 graphics calculator, and the respiration monitor to determine patterns and generalizations from data and graphs of respiration.

Links to Standards:

- **Mathematics as Problem Solving**
Students will demonstrate their ability to model a real-world phenomena from variations of the sinusoidal curve in respiration experiments.
- **Mathematics as Communication**
Students will exchange ideas, discuss, and examine transformations of the sinusoidal curve.
- **Mathematics as Reasoning**
Students will analyze graphs and data sets in order to make conjectures about significant properties of respiration.
- **Mathematical Connections**
Students will relate the properties of periodic functions to the process of breathing and value the connections between mathematics and the biological sciences.
- **Functions/Trigonometry**
Students will model the process of respiration with a periodic function and analyze the effects that changes in the breathing rate and volume of air have on the graph and its critical values.
- **Statistics**
Students will draw inferences from graphs of respiration under a variety of conditions. As an extended activity students will use curvefitting and correlation.

Links to Maryland High School Mathematics Core Learning Goals:

- **1.1:** The student will analyze a wide variety of patterns and functional relationships using the language of mathematics and appropriate technology.
- **1.1.1:** The student will recognize, describe, and extend patterns and function relationships that are expressed numerically, algebraically, and geometrically.
- **1.1.2:** The student will represent patterns and functional relationships in tables, as a graph, and/or by mathematical expression.
- **1.1.4:** The student will describe the graph of a non-linear function in terms of basic concepts of maxima and minima, roots, limits, rate of change, and continuity.
- **1.2:** The student will model and interpret real-world situations using the language of mathematics and appropriate technology.
- **3.1:** The student will collect, organize, analyze, and present data.

- **3.1.1:** The student will design and/or conduct an investigation that uses statistical methods to analyze data and communicate results.
- **3.2.2:** The student will make predictions by finding and using a line of best fit and by a given curve of best fit.

Grade/Level:

Algebra I, Algebra II, Trigonometry, Pre-Calculus

Prerequisite Knowledge:

Students should have working knowledge of the following:

- The TI-82/83 graphics calculator
- Transformations of periodic functions

Objectives:

Students will:

- be able to interface the TI-82/83 graphics calculator with the CBL and the Vernier respiration belt.
- collect data from these instruments.
- describe the graph of the function generated by the data.
- identify domain and range.
- approximate the amplitude and period of the graph.
- analyze the graphs and compare the results of several trials under varying conditions.

Materials/Resources/Printed Materials:

- CBL unit
- TI-82/83 graphics calculator with unit-to-unit link cable
- Vernier respiration belt
- Vernier Biology Gas Pressure Sensor
- Program: CHEMBIO
- STUDENT INSTRUCTION WORKSHEET
- “This will take your breath away” ANALYSIS
- Stepping stool

Development/Procedures:

1. Have a brief discussion of the process of respiration.
2. Make sure each student has a copy of CHEMBIO on their calculator.
3. Demonstrate the procedure for the equipment set-up.
4. Hand-out STUDENT INSTRUCTION and “ This will take your breath away “ ANALYSIS.
5. Divide students in groups of three or four. Each group should have a recorder, a “breather “ and calculator and CBL operator.

6. Perform one trial of the experiment on the overhead graphics calculator where each group is working with the instructor.
7. The students will perform the experiments and the analysis.

Performance Assessment:

As the students perform the experiment in groups the teacher will circulate in the classroom to make sure students are focused and following the correct procedures. The analysis worksheet will be collected and evaluated. Teachers may also have each group use an overhead transparency to share one of their graphs with the class.

Extension/Follow Up:

Have student find a sine regression on the TI-83 which best fits the data. It is possible to use the ALLSELECT program to isolate a portion of a complex curve which could be analyzed.

Use the respirometer in conjunction with the respiration belt to determine if there is a correlation between volume of air moved and the graph generated by the CBL. If a positive correlation exists, then vital lung capacity and tidal volume could be approximated.

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This Will Take Your Breath Away
Instruction Sheet

1. Hook up the CBL , TI-82/83 graphics calculator, respiration belt and pressure sensor as the teacher instructed.
2. Turn on the calculator and the CBL.
3. Press PRGM on the calculator and select CHEMBIO from the menu.
4. You will be given an introductory screen to the program and will be prompted to press ENTER to continue.
5. Press 1 to SET UP PROBES. (You will run through a series of entries in this menu.)
ENTER NUMBER OF PROBES: 1 press ENTER
SELECT PROBE: 7 (MORE PROBES)
 7 (MORE PROBES)
 4 (RESPIRATION BELT)
ENTER CHANNEL NUMBER: 1 press ENTER
CALIBRATION: 1 (USE STORED)
6. You should now be back to the main menu. Press 2 to COLLECT DATA.
7. In the DATA COLLECTION MENU press 2 to give you the TIME GRAPH setup.
8. In this menu you will do the following:

ENTER TIME BETWEEN SAMPLES IN SECONDS: .5 press ENTER
ENTER NUMBER OF SAMPLES: 50
Read the next screen and press ENTER.
(*Note: For trial 2 the number of samples should be 100.)
9. You should now be in the CONTINUE menu. Press 1 to use TIME SETUP.

Y MIN= 760 Press ENTER
Y MAX = 850 Press ENTER
Y SCL = 10 Press ENTER
10. When all the equipment and participants are ready, Press ENTER to begin collecting data.
11. Your breathing pattern will be determined by the trial you are completing.
12. When the CBL has completed its data collection the calculator will display the following:

TIME IN L1
RESPIRATION IN L2
Press ENTER to continue.
13. The calculator will then output the graph of the experiment.
14. Your group should now move to the Analysis Sheet.

This Will Take Your Breath Away
Analysis Worksheet

Answer each of the following questions completely (be sure to include the appropriate units). Each graph must include labels and scales. In order to get the most accurate readings the “breather” should not move or talk during each trial.

Trial One: Resting

Choose a comfortable, resting position while collecting the data for this experiment.

1. Sketch the graph on the grid provided below.



2. Calculate the number of breaths/minute by using the trace button . Determine the elapsed time between the first and last valley and record. _____

How many breaths were taken during this time interval? _____

To calculate BPM : Multiply the quotient of the elapsed time and the number of breaths by 60. BPM: _____

3. Use trace to determine if the peaks for each breath are consistent. Record the y-value of the lowest and highest peak below.

Lowest: _____ Highest: _____

Were the peaks for each breath consistent ? Explain your answer.

4. Use trace to determine if the valleys for each breath were consistent. Record the y-value of the lowest and highest valley below.

Lowest: _____ Highest: _____

Were the valleys for each breath consistent? Explain your answer.

Trial 2: Holding your breath

5. How do you think the graph will look while holding your breath? Make a **prediction** for this experiment and sketch below.

As you press ENTER to start collecting data hold your breath for approximately 20-25 seconds and then breathe normally for the remainder of the experiment.
(*Note: The number of samples should be 100 for this trial.)

6. Sketch the graph of the actual experiment below.

7. How well did your prediction approximate the actual graph of the experiment?

8. Calculate the breaths per minute after holding your breath and record below.

BPM after you held your breath:

If there is a difference in the BPM for Trial 1 and Trial 2? How do you explain the differences?

9. Were there any differences in the peaks and valleys from Trial 1? Explain your answer.

Trial 3: Deep and Shallow Breaths

10. How do you think the graph will look while breathing deeply for half the experiment and shallow for the remainder of the time? Make a sketch of your **prediction** below.



For the first half of the experiment take long deep breaths and for the remainder of the time take short shallow breaths.

11. Sketch the graph of your experiment below.



12. How well did your prediction approximate the actual graph of the experiment?

13. How are the BPM's different for deep and shallow breathing? How do you explain the differences?
14. Are there any differences between the peaks and valleys for the deep and shallow breathing? Explain.

Trial 4: Exercise

Take 50 steps up and down on the steeping stool or jog in place for 2 minutes. Repeat the experiment.

15. Sketch the graph of the experiment below.



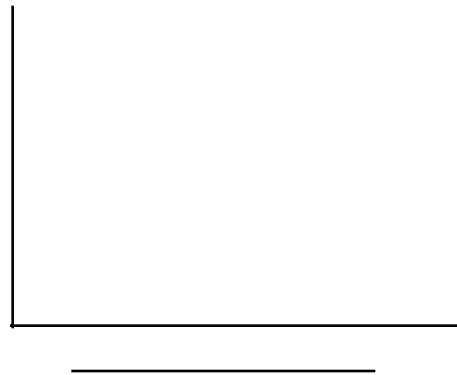
16. Based on the data and the graph from trial 1 and trial 4, in what way does exercise affect the BPM and the peaks and valleys? Explain your answer.
17. After performing the four experiments, what generalizations can you make about respiration ?

This Will Take Your Breath Away
Comparisons

Answer each of the following questions completely (be sure to include the appropriate units). Each graph must include labels and scales. Identify the two subjects in the spaces provided under the graphs.

1. Make a comparison between the data and the graphs of _____
for trial _____ .

Sketch the graphs below.



2. Do you notice any similarities in the graphs? Explain your answer.
3. Do you notice any differences in the graphs? Explain your answer.
4. What may have been contributing factors which explain your answers to questions 2 and 3?

This Will Take Your Breath Away
Trigonometry Extension

1. Find the Regression equation of the graph of trial one and record it below. (Round answer to the nearest hundredth.)

Sin Regression: _____

2. Make a sketch of the Sine regression graph below.



3. How well does the regression equation approximate the actual graph? Explain your answer.
4. What factor in the breathing process could cause a change in the amplitude?
5. How do the BPM's affect the period and frequency?
6. Look at Trial 4. How are the amplitude, period and frequency affected by the change in breathing pattern?

Respiratory System

“Only 2-3 percent of the total energy expended by the body is required for normal, quiet respiration. But during heavy exercise that need increases as much as 25 times. In normal breathing, 8,000 millimeters or 15 pints of air are circulated through the lungs each minute.”

The Respiratory Process

Respiration isn't simply breathing. The term also describes all the processes associated with the release of energy in the body. The blood carries food and oxygen to the cells so they can produce energy for their needs. The simplified process is: food + oxygen = carbon dioxide + water + energy.

Oxygen is needed in the cells to break carbohydrates and fats into energy. Carbon dioxide is a byproduct of metabolism in the cells, but while it is a waste product in man and animals, carbon dioxide is necessary for plant respiration. Plants release oxygen, their waste product, and the cycle of mutual benefits between plant and man is repeated continuously.

Gas exchange occurs in the lungs. The right side of the heart pumps blood with a high concentration of carbon dioxide into the lungs. The carbon dioxide is replaced with oxygen. The blood changes from a dark red to a bright red color, indicating hemoglobin has picked up the oxygen. The oxygen-enriched blood pumped through the left side of the heart and then circulated throughout the body.

The carbon dioxide is then exhaled. The respiratory system is sensitive to the amount of carbon dioxide in the blood. If this amount rises, the breathing response will increase so that more oxygen is available for energy metabolism.